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DYNAMICS OF BIODIVERSITY LOSS AND FINANCIAL SYSTEM STABILITY NEXUS IN DEVELOPING COUNTRIES

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Abstract

Global warming has been escalating along with its major damaging effects. One such effect is its negative impact on economic growth. This paper is premised on the fact that, in addition to its threats to economic growth, climate change can affect financial institutions unfavorably and become a significant cause of financial risk. Therefore, this study aims to investigate the nexus between the dynamics of biodiversity loss and financial system stability in sub-Saharan Africa (SSA). Using annualized data from World Bank indicators, the study adopted panel techniques. The panel data results indicate that carbon emission has no positive impact on bank non-performing loans in the short run. The findings strongly support that carbon emission in this region does not contribute significantly to financial instability in the short run. This shows that Africa may well be able to assist the world to counteract climate change by providing an essential carbon sink while resisting deforestation and effectively managing the continent's marine resources. Based on the research findings, it is recommended that policymakers in SSA should promote economic activities that reduce climate fragility while ensuring sustainable economic development.

Keywords Africa, climate change, deforestation, financial stability, panel data

JEL Classification C80, F64, F65

INTRODUCTION

For any economy to advance its trade and strengthen local capacities, finance plays a key role. Therefore, financing for sustainable development is crucial and has been at the forefront of the 2030 agenda for sustainable development (Bordon & Schmitz, 2015). The 17 Sustainable Development Goals (SDGs) for environmental, economic, and social development are crucial, considering the magnitude of biodiversity loss. For developing countries, the basis for the SDG agenda for economic, environmental, and social development is a stable financial system. Recently, financial institutions have been severely threatened, owing to the fragility of the climate occasioned by biodiversity loss.

The last 50 years have witnessed unprecedented biodiversity loss owing to human activities meddling with nature and the entire ecosystem. Similarly, the climate has been severely altered due to the constant spread of chemical pollutants and organic matter. Therefore, the terms biodiversity loss and climate change have become inseparable (Magnan et al., 2021). The fragility of climate change cuts across all sectors of the economy. The real sectors of the economy are burdened with both direct and indirect consequences of climate risk. These physical risks also affect the stability of financial institutions by causing economic losses, making it challenging for investors to redeem loans they obtain from financial institutions. Non-performing loans threaten banks' stability. These financial institutions play an important intermediary role by providing investible funds in an economy.

Climate risks predispose banks to fail in the repayment of their loans owing to physically associated climate risks (NGFS, 2019). Climate change causes mostly the vulnerable to be affected because of their high dependency on natural resources for sustenance. However, climate change poses environmental degradation, which denigrates the ability of the poor to access natural resources. Climate risks, therefore, tend to worsen poverty. World leaders face challenges in eradicating poverty through sustainable development goals (SDGs). The first goal of the SDGs is to achieve a state of no poverty, and the second is to achieve zero hunger, all by 2030. Climate risk is a major constraint in realizing these goals by 2030 (Sida, 2019).

Extant literature states that global warming reduces well-being (Dafermos et al., 2018; Gelzinis & Steele, 2019). The need to evade a global environmental disaster prompted several researchers and policymakers to focus on reducing greenhouse gas (GHG) emissions. According to Bhattacharya et al. (2017), greenhouse emissions are the primary source of climate change. Therefore, basic moves towards mitigating GHG are crucial; otherwise, emissions could double by 2035 from their pre-industrial level (UN, 2015). The fear of reaching the threshold of ever-rising temperature levels has been expressed by environmental experts, who claim that the impact will severely affect all sectors of the economy. Worse, the rising temperatures will soar sea levels, intensify hurricane occurrences, and increase drought and wildfire incidents. All these results could trigger a significant reduction in the quality of life (Li & Wu, 2017; Lu et al., 2017).

In developing continents like Africa, environmental changes due to climate risk, with increasing pollution levels, are affecting the economy. Although African countries, in general, have not contributed immensely to the world's emissions owing to their meager economic activities, they are amongst the nations facing the consequences of climate change (Bhattacharya, 2022). In sub-Saharan Africa (SSA), climate change will undoubtedly be one of the most significant risks to achieving sustainable development goals during the current decade (AfDB Group, 2020).

Some of the challenges SSA faces include vulnerability and economic losses, mainly affecting low-income people. The region seems to have a weak capacity to cope with climate change owing to poor infrastructural development and apathy from their political leaders toward climate change. Despite all these uncertainties in SSA, little interest has been documented in the literature concerning climate risk and financial stability. Most countries within SSA have the lowest gross domestic product across the globe. It is vital to investigate SSA because air pollution has maintained a rising trend owing to factors like energy use. Studying SSA was motivated by limited studies in this region. While extant literature on carbon emission in developed countries exists, there has been little discussion in this respect concerning SSA thus far.

The extant studies show that most of the attention has been paid to the impact of carbon emission on an economy, carbon emission and renewable energy, financial progress, economic growth, environmental degradation, and the growth of financial systems. On the other hand, financial system stability has received little attention, if any, in the developing economy. This critical gap should, therefore, receive attention. This study was undertaken to fill the gap created by limited empirical studies that could drive policy. The contribution of this paper to the body of knowledge is to show the empirical evidence of the impact of biodiversity loss on financial stability.

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1. LITERATURE REVIEW

The 21st century faces a substantial challenge concerning addressing climate change, which has triggered global warming. The consequences of global warming have become noticeable within the environment. According to Lagarde (2020), the number of calamities triggered by natural hazards rose from 249 in 1980 to 820 in 2019. Gas and greenhouse emissions affect the entire globe. Indeed, a notable cause of global warming is carbon emissions. The emission of CO_2 is intense due to burning coal and natural gases. Developing countries are primarily affected by environmental degradation, as this is not only the concern of industrialized nations (Owusu et al., 2016; Sarkodie & Strezov, 2018). Many associated issues can worsen environmental degradation. For instance, they are population explosion, deforestation, emission from industrial sectors, transportation, and many more (Khan et al., 2019). Most of these natural calamities accelerate environmental degradation. The negative impacts of these calamities, which relate to environmental degradation, can be perceived by the valuable lives and agricultural activities destroyed. Hence, the current level of degradation necessitates universal action.

Climate change has prompted many countries to become signatories in the effort to reduce greenhouse gas emissions as a way of curtailing global warming. To mitigate climate change, some global actions have been established. The most significant is the Paris Agreement (UN, 2015), which targeted to minimize below 2°C the rise in the global average temperature. Following this global action is the role of the UN's Intergovernmental Panel on Climate Change (IPCC). In a similar vein, the target to achieve net zero emissions by 2050 was anchored by the EU. It was hoped that 1 trillion euros could be mobilized by The Europe Investment Plan to achieve zero emissions. Some of the characteristics of economies that would be severely affected are countries that are not diversified and have the minimal climate-resilient infrastructure (NGFS, 2019).

While this is a global concern, many economies are reluctant to minimize energy utilization for productive services. Reduction of production to address CO_2 emission could be perceived as compromising developmental goals. Whereas economic activities are essential for sustainable development, productive activities can promote climate risk through associated systemic risks. These challenges are present in both developing and developed economies. In developing economies, many foreign investors manufacture on a large scale, constituting emissions.

Conversely, unplanned agricultural activities, which contribute immeasurably to economic growth, remain a strong driver of climate risk. Again, the massive importation of second-hand vehicles is equally a major source of carbon emission in most developing countries, particularly in SSA. Furthermore, weak governance and a lack of political will constrain good policy to address the issues. Many used vehicles emitting carbons strongly due to age and usage are imported into the African continent. This affects the environment negatively, creating climate fragility as a result of global warming.

1.1. Climate change and financial stability

In the new global economy, climate change has become a central issue that affects the financial system. A serious discussion and analysis of the issue were presented by Gelzinis and Steele (2019). They argued that rising natural disasters and environmental shifts would advance asset decays. Asset deterioration will compel borrowers not to redeem their financial obligations, triggering non-payment and losses for these credit portfolios. Climate change threatening the financial system's stability may become too far-reaching to stabilize the environment if neglected. European banks have suggested a need to achieve a financial system that could be strong enough to withstand climate risks. Similarly, Sevillano and González (2018) proposed the need to evaluate and manage banks' exposure to climate fragility.

A menace concerning climate risk is that its transitional impact is felt in the long run and not in the short run, which is the case with the associated financial system risk. Climate risk translates into market risk, credit risk, as well as operational risk, and not necessarily new types of risks. In banks, for instance, operational risks endanger the busi-

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ness continuity of a financial institution. This is not unconnected to extreme weather conditions that could hinder its business activities or that of any of its subsidiaries. Again, this would bring about a substantial drop in collateral value. Credit risk, conversely, has different dimensions. Policy on disclosure may force a firm to upgrade to new technology, thereby incurring higher costs, which leads to a reduction in profit, and higher chances of default risk. A ban on some technologies that emit carbon may also occur, compelling companies to acquire new environmentally friendly technology means.

Global warming affects the entire ecosystem and has recorded economic disruptions and investment diversions (Gelzinis & Steele, 2019). Disruptions to economic activities pose a threat to financial system stability (Batten & Vo, 2016). While financing is vital to achieving specific sustainable development goals, it can lead to new systemic risks by driving climate risk. When banks fund products that are not environmentally friendly, they constitute climate fragility. Recent developments in climate fragility have heightened the need to allay climate risk, as it affects economic stability. This necessitates the diversion of investments from the productive sector toward climate change adaptation (NGFS, 2019). A careful review of the literature revealed many implications of climate risk, such as deteriorating agricultural yields through bad weather, natural disasters, floods, and rising sea levels.

Similarly, there is macroeconomic and fiscal instability owing to social welfare and infrastructure destruction. In some jurisdictions where carbon tax policy is effective, sectors that utilize carbon fuel predominantly are affected more. As a result, such industries face tightened standards and disclosures (IMF, 2019).

A growing number of empirical studies have examined the impact of carbon emissions on the economy, resulting in mixed findings. For instance, Acar and Lindmark (2017) studied the impact of CO_2 in OECD economies. Their findings suggest that a decrease in environmental degradation would be achieved by encouraging the use of clean energy. Destek (2017) claimed that transportation and CO_2 emissions positively affect economic growth. Adopting an ARDL model, Işik et al. (2017) reported that many factors like economic growth, international trade, and financial system growth all contribute to promoting carbon emissions in Greece. The research of Işık et al. (2019) is a strong pointer toward a positive impact of CO_2 on Florida's economy, while fossil energy has a negative impact on CO_2 emission in Texas. Studying the impact of energy consumption and economic growth on carbon emission, Bhat (2018) employed an ARDL estimation technique and obtained a direct relationship between non-renewable energy consumption, labor, per-capita income, and CO_2 emission. Arouri et al. (2012) researched the relationship between carbon dioxide emissions, energy consumption, and the real GDP of MENA. They reported a long-term positive impact on energy consumption and $CO_{2,}$ while the results also show that CO_2 emission reductions per capita were achieved.

Sulaiman and Abdul-Rahim (2017) investigated the Malaysian economy and discovered a relationship between energy consumption, economic growth, and carbon emission. Their study revealed a significant positive relationship between energy consumption, economic growth, and CO_2 emission. Charfeddine and Kahia (2019) employed the panel vector autoregressive (PVAR) model to investigate the impact of renewable energy and financial development on carbon emission and economic growth in MENA's economy. Their findings suggest that renewable energy consumption and financial development exerted a minimal effect on CO_2 in MENA. Climate fragility is a primary concern for global leaders. Financing investments is essential to achieve sustainable development; therefore, the risk of fostering financial instability should receive attention as a matter of urgency. While this has received serious attention and policy directions in developed countries, SSA appears to be lagging behind in this respect.

Figure 1 is a graphic representation of carbon emissions and non-performing loans. There is an oscillatory movement of carbon emissions in SSA. Both carbon emission and non-performing loans mimic each other. This is an indication that carbon emission increases the possibility of non-performing loan.

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Source: Authors' computation.

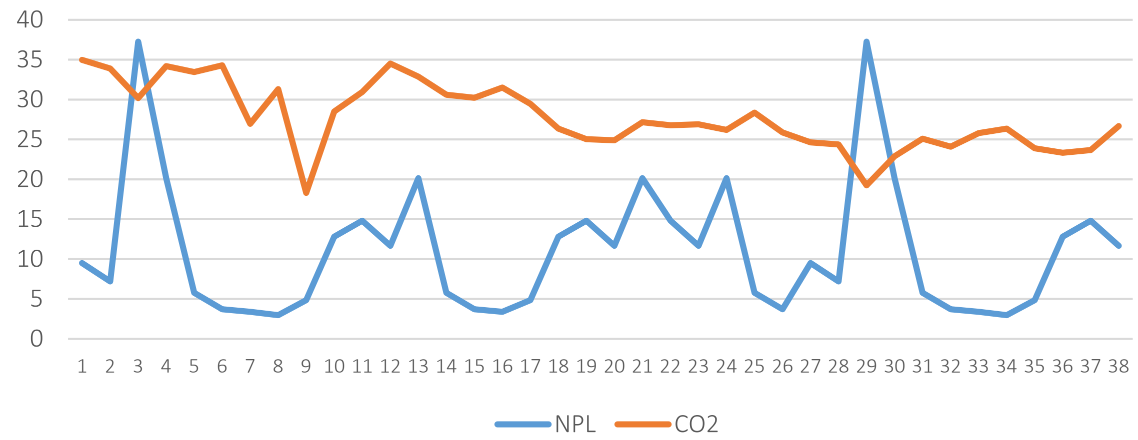

Figure 1. Carbon emissions and non-performing loans

2. METHODOLOGY

The study used panel datasets from SSA, obtained from the world development indicators. The selection of variables used in this study was guided by both theoretical and empirical evidence. This study is modeled in line with Brooks (2014) while using the fixed effect model, as well as the random effect of panel data analyses. The baseline model is presented in equation 1:

$$Y_{it} = \alpha + \beta x_{it} + \varphi_i. \quad (1)$$

The time-varying intercept is represented by ϕ_i. The fixed effect model can be substituted by using the following variables:

$$NPL_{it} = \alpha + \beta_1 LnCO2_{it} + \beta_2 LnGDP_{it} + \\ + \beta_3 LnFDI_{it} + \beta_4 Inf_{it} + \beta_5 LendingRT_{it} + \mu_{it}, \quad (2)$$

where *NPL*: is bank non-performing loans to total gross loans (%); *CO2*: is CO2 emissions (metric tons per capita); *GDP*: refers to that annual percentage growth rate of GDP per capita; *FDI*: is foreign direct investment, net inflows (% of GDP); *Inf*: refers to inflation, as measured by the consumer price index; *LendingRT*: is the lending rate of the bank that usually meets the short- and medium-term financing needs of the private sector; and μ_{it} is the error term.

The model selection between the fixed effect and the random effect was made by employing the Hausman test. The model is presented here in line with Asteriou and Hall (2007).

$$H_{stat} = \left(\beta^{FE} - \beta^{RE}\right)\left(Var\left(\beta^{RE}\right) - 1\right) \times \\ \times \left(\beta^{FE} - \beta^{RE}\right) - x^2. \quad (3)$$

The Hausman test represents the distance measure between the fixed and random effects. H_0 indicates a better random effect, while an H_1 shows a better efficient and constant fixed effect.

3. RESULTS

A summary of the basic statistics results of the variables under investigation is presented in Table 1.

Table 1. Descriptive statistics

Source: Authors' computation.

Variables	Mean	Max	Min	Std. dev	Observations
NPL	14.29434	52.09766	−1.32367	9.302898	142
INFT	2.652476	30.69531	−99.7814	18.21227	142
LEND_TR	21.08153	131.7303	−1.5371	30.13333	142
GDPC	−0.32354	18.16105	−36.5569	5.722271	142
FDI	2.25555	12.7979	−6.36988	3.23174	142
CO2	1.166267	9.707222	0.039617	1.671449	142

Table 1 presents the study's descriptive statistics, revealing that the average value of *NPL* is far from *CO2*. This indicates that *CO2* may be contributing minimally to *NPL*. The average value of *LEND_TR* most likely refers to *NPL*. The average rate of *FDI* and *NPL* are far apart. *FDI* as an international source of loans may not necessarily influence *NPL*. The standard deviation for all the variables shows deviation from the mean and explains economic fluctuations for the period under review. This is evident while observing the standard deviation of *NPL*, *INFT*, *LEND-TR*, *GDPC*, *FDI* and *CO2*.This observation is obvious when the maximum value of *NPL* (52.09) is reconciled with the raw data used for analysis, which correlates with the economic reality of the said period. The global pandemic has affected all countries, which has increased the phenomenon of non-performing loans, as many businesses ceased to exist. Though an external factor, the pandemic caused difficulties for debtors to repay their loans, which originated from financial institutions. Bad credit outcomes can promote financial instability owing to non-performing loans. In fact, both foreign direct investment and gross domestic product were affected by the Covid-19 pandemic.

3.1. Unit root result

The study adopted a panel unit root test. This test has remained a vital test amongst researchers and economists. With these tests, panel-specific results were derived. Different panel unit root tests were adopted, and their results are presented in Table 2.

The unit root result indicates that all the variables were stationary at all levels. Estimation of the panel least square, therefore, was correctly selected, considering the summary that the unit root presented.

3.2. Panel regression output

The panel least square results were analyzed to show the impact of climate risk on financial stability in SSA (Table 3).

Hausman stat = 51.892 (0.00). The choice model is a fixed effect. Considering the results of the Hausman test, the best model is a fixed effect. This is in line with the significant level of the test statistics. The results influenced the choice of fixed effect over random effect.

The panel regression results in Table 3, namely the R2, show that the independent variables are jointly responsible for a 76% variation in the dependent variable. By implication, there is an explained variation of 76% and an unexplained variation of 24%. Considering the independent variable of *LNC*02's natural log of carbon emission, an inverse relation-

Table 2. Summary of unit root test

Source: Authors' computation.

Variable	Levin and Lin (1993) (test statistics)	Breitung (test statistics)	ADF (test statistics)	PP	Inference
NPL	–12.91	–3.43	65.13	121.51	1(0)
LEND-TR	–24.09	–2.10	39.93	62.57	1(0)
INFT	–5.88	–2.25	31.88	51.76	1(0)
GDPC	–11.84	–2.94	47.78	97.42	1(0)
FDI	–12.91	–3.44	65.13	121.51	1(0)
CO2	–4.99	–2.80	55.43	55.43	1(0)

Table 3. Panel least square results

Source: Authors' computation.

Variables	Model 1	Model 2	Model 3
	OLS	FE	RE
*LNC*02	–0.02(0.00)	–0.208491(0.00)	–0.049006(0.00)
GDPC	–0.77(0.00)	–0.383528(0.00)	–0.518513(0.00)
FDI	0.02(0.92)	–0.213716(0.28)	–0.005214(0.97)
LEND_TR	0.03(0.21)	0.116056(0.39)	0.012196(0.83)
INFT	–0.12(0.00)	–0.117543(0.06)	–0.063581(0.10)
C	12.36(0.00)	–3.257572(0.31)	10.49402(0.0)
R-squared	0.31	0.765458	0.248557
F-stat	12.42	23.8(0.00)	8.99
No. of observations	142	142	142

Note: P-values are in parentheses.

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ship exists between carbon emission and non-performing loans. The result is significant, though with a negative relationship. This indicates that the result is inconclusive. The gross domestic product per capita (*GDPC*) has a negative and significant relationship with *NPL*. This result is inconclusive as the global recession is a major contributor to *NPL*. The relationship between *FDI* and *NPL* is negative and insignificant. This result captures the reality between the two variables. *FDI* does not depend on domestic credit often; however, they rely on international financial intermediaries.

FDI has a funding source that is different from the domestic one. Hence, it cannot be a driver for *NPL*. *FDI*s that are environmentally friendly should be encouraged where the inflation rate is negative or insignificant. Inflation creates uncertainty, while high inflation discourages borrowing and interest payments on already borrowed funds. Issued loans have a high chance of turning into bad debt due to high inflation. This justifies the obtained relationship.

The overall regression is found significant, considering the F-statistics (23.8). Furthermore, the associated probability value is 0.000. This indicates that the results can be used for meaningful analysis.

4. DISCUSSION

Principally, human activities promote greenhouse gas emission which gets stored over a period and heat up the climate. Carbon emission is a powerful driver of climate change in industrialized and developing economies. The apriori expectation of the relationship between non-performing loans and climate risk proxied by CO_2 is positive. This has remained a general knowledge. This study's findings revealed an inverse relationship. The above finding seems to contradict Gelzinis and Steele (2019), who opined that borrowers would be unable to redeem their financial commitments owing to climate-related crises. They proposed a positive relationship between climate-related risks and non-performing loans. Essentially, the expected positive relationship between climate risk and banks' non-performing loan stems from the fact that natural disaster affects forest, land and environment in general. What was deduced from the findings is that there are other drivers of NPL that may have influenced the obtained result. Other determinants like government policies and macroeconomic conditions, may be contributing to non-performing loans in SSA. The relationship with CO_2 in the short run is negative. SSA is more influenced by climate fragility owing to external shocks. Although there is an inverse relationship now, the dynamics might change in the long run as SSA becomes more exposed to climate change. SSA's exposure to climate risk is more because of external rather than internal effects.

The planet is under severe threat owing to climate change. Both human welfare and economic-related issues face challenges occasioned by climate change. From the look of things, all countries will be negatively affected by climate change if drastic measures are not taken. Presently, the effects of climate change, as well as how the environment will react, remain uncertain. Although there seem to be some global publicity campaigns to take urgent measures toward reducing greenhouse emissions, this seems insufficient, especially in developing countries. One explanation could be that climatic risk is more pronounced in the long run, leaving people with the misconception that it is a once-off occurrence. For instance, deforestation can worsen biodiversity and boost CO_2. In addition, most SSA countries have become financially unstable due to the recurring global financial crisis and, recently, the Covid-19 pandemic. All these issues have contributed to weakening the financial system even further.

The finding on gross domestic product per capita is consistent with Gelzinis and Steele's (2019) findings, which reported a negative relationship between GDPC and CO_2, owing to recorded economic disruptions due to the impact of global warming. This study's finding on GDPC is consistent with this position. However, Acar and Lindmark (2017) reported that degradation in an environment is promoted by advancement in the use of less clean energy. Similarly, these findings contradict Sulaiman and Abdul-Rahim (2017), who reported a positive relationship between economic growth and carbon emission.

The findings on the interest rate and inflation showed a negative relationship with carbon emission in contrast to the findings of Muhammad et al. (2020). Interestingly, the findings agree with Destek (2017) and Işik et al. (2017) that economic growth and FDI contribute heavily toward carbon emissions.

CONCLUSION

As a policy requiring urgent attention, environmental factors should feature significantly within each country's related regulations or policies. Substantial interventions are required to mitigate climate risk. Governments must not merely pay lip service to such demanding interventions and incentives toward climate control. Addressing most systemic risks should motivate regulators to achieve near-zero emissions.

The highly industrialized countries of the world contribute much more to carbon emissions than the less industrialized economies, where SSA belongs. This low-resistant path becomes an opportunity for SSA to advance to more environmentally friendly economic growth. Attention must be drawn to climate-related risks while seeking development for the sake of organization adaptation and sustainability in the face of climate change. Robust institutional structures should be used toward the attainment of extraordinary feats. Improvement of organizational financial complexity should become a priority in SSA, in addition to adopting international standards and guidelines for effective coordination.

SSA has so much to contribute to the world's efforts toward mitigating climate risk, for example, by providing an essential carbon sink. This could be achieved if they minimize the level of deforestation and efficiently manage marine their resources. Winning this great battle requires collaboration amongst all global stakeholders.

AUTHOR CONTRIBUTIONS

Conceptualization: Chinwe R. Okoyeuzu.
Data curation: Chinwe R. Okoyeuzu.
Formal analysis: Chinwe R. Okoyeuzu.
Funding acquisition: Wilfred I. Ukpere.
Investigation: Chinwe R. Okoyeuzu.
Methodology: Chinwe R. Okoyeuzu.
Project administration: Wilfred I. Ukpere.
Resources: Wilfred I. Ukpere.
Software: Wilfred I. Ukpere.
Supervision: Wilfred I. Ukpere.
Validation: Wilfred I. Ukpere.
Visualization: Chinwe R. Okoyeuzu, Wilfred I. Ukpere.
Writing – original draft: Chinwe R. Okoyeuzu.
Writing – review & editing: Wilfred I. Ukpere.

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